

**Harding Lawson Associates**

October 29, 1998

39856 210

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75 Hawthorne St.
San Francisco, California 94105-3901

**Baldwin Park Operable Unit
San Gabriel Basin, California
Phase 2 Treatability Study Work Plan
Pilot-Scale Groundwater Treatment System**

Dear Mr. Praskins,

Please find enclosed a copy of the Draft Phase 2 Treatability Study Work Plan for the Baldwin Park Operable Unit (BPOU) prepared by Harding Lawson Associates (HLA) on behalf of the BPOU Steering Committee. Please review this document and provide your comments to Don Vanderkar. If you have any questions, please call John Catts at (949) 260-1800 or me at (303) 293-6128.

Sincerely,

HARDING LAWSON ASSOCIATES

A handwritten signature in black ink, reading 'Jim Michael', with a stylized flourish at the end.

James I. Michael, P.E.
Managing Principal Engineer

cc: John Catts

PHS2WPCVRLET/KSC

Draft
Phase 2 Treatability Study Work Plan
Pilot Scale Groundwater Treatment System
Baldwin Park Operable Unit
San Gabriel Basin, California

Prepared for

Baldwin Park Operable Unit Steering Committee

HLA Project No. 39856 210

DRAFT

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CONTENTS

1.0	INTRODUCTION.....	1-1
2.0	HISTORY OF PERCHLORATE ISSUES.....	2-1
2.1	Distribution of Perchlorate in the BPOU.....	2-1
2.2	Toxicity/Provisional Action Level.....	2-2
3.0	PERCHLORATE TREATMENT BY BIOLOGICAL REDUCTION	3-1
3.1	Conceptual Model of Biological Perchlorate Reduction	3-1
3.2	Phase 1 Treatability Study Results.....	3-4
3.3	Full-Scale System in Sacramento.....	3-5
4.0	PHASE 2 OBJECTIVES	4-1
4.1	Confirm Destruction/Removal Efficiencies	4-1
4.2	Establish Operating Parameters.....	4-2
4.3	Collect Data to Support Permitting as Potable Water Source	4-4
4.4	Collect Data to Support Design of Full-Scale System	4-4
5.0	TREATMENT SYSTEM DESIGN	5-1
5.1	Conceptual Design.....	5-1
5.2	Treatment Unit Processes.....	5-1
5.2.1	GAC/FB Bioreactor	5-1
5.2.2	Multimedia Filters.....	5-2
5.2.3	UV/Oxidation	5-3
5.2.4	Liquid-Phase Granular Activated Carbon Adsorption.....	5-3
5.2.5	Disinfection	5-4
5.3	Multi-Barrier Treatment System.....	5-4
5.4	Detailed Design.....	5-5
6.0	TREATMENT EQUIPMENT DESCRIPTION	6-1
6.1	Extraction Well	6-1
6.2	Influent Flow Control Tank.....	6-1
6.3	GAC/FB Bioreactors	6-1
6.4	Multimedia Filters	6-3
6.5	UV/Oxidation System	6-5

6.6	GAC Contactors	6-5
6.7	Disinfection System	6-6
6.8	Reclamation System	6-6
6.9	Flow Equalization Tanks and Transfer Pumps	6-7
7.0	PERMITTING	7-1
7.1	Construction Permits	7-1
7.2	Discharge Permit.....	7-1
7.3	Ethanol Permit	7-1
7.4	Certification of Additives	7-1
7.5	DHS Operating Permit	7-2
8.0	OPERATION AND MAINTENANCE MANUAL.....	8-1
9.0	REFERENCES	9-1

TABLES

6.1	Preliminary Pilot System Design Criteria
6.2	Anticipated Pilot System Influent Water Quality
8.1	Preliminary Summary of Analytes and Methods

FIGURE

5.1	Phase 2 Pilot System Process Flow Diagram
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APPENDIX

A	PRELIMINARY DRAWING LIST AND PRELIMINARY LIST OF SPECIFICATIONS
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1.0 INTRODUCTION

For the past several years, the Baldwin Park Operable Unit Steering Committee (BPOUSC), the U.S. EPA Region IX (EPA), Three Valleys Municipal Water District (TVMWD), and the Metropolitan Water District of Southern California (MWD) have been planning a combined groundwater remediation and water supply project in the San Gabriel Basin, California. Project planning was initiated in response to a requirement of EPA to remediate various plumes of volatile organic compounds (VOCs) in groundwater in the cities of Azusa and Baldwin Park. These plumes extend from north of Interstate 210 in the city of Azusa southwest to locations in the vicinity of Interstate 10 in the city of Baldwin Park. This area is called the Baldwin Park Operable Unit (BPOU).

The BPOUSC was in the process of negotiating agreements for the project with EPA, MWD, and TVMWD when in June 1997, concentrations of perchlorate ion, above the State of California Department of Health Services (DHS) provisional action level of 18 micrograms per liter ($\mu\text{g/l}$), were detected in BPOU groundwater. Before the project could move forward, the potential impact of perchlorate on the conceptual project design had to be evaluated. At the time it was discovered in BPOU groundwater, perchlorate was considered troublesome because no treatment technology had been demonstrated to be effective in reducing concentrations of perchlorate to the provisional action level.

Pilot scale perchlorate treatability testing was performed at the Aerojet-General Corporation (Aerojet) facility near Sacramento, California in 1997. The technology is a biological reduction process using a fixed film attached to granular activated carbon and operated as a fluidized bed (GAC/FB) bioreactor. This pilot-scale test demonstrated the technology was effective in treating perchlorate in groundwater. There were, however, several important differences between objectives of this previous pilot-scale work and current objectives for the BPOU project. First, the flow rate was 0.1 percent of that needed in the San Gabriel Basin. Second, the influent perchlorate concentration was over 100 times that expected in the San

Gabriel Basin. Third, the Pilot System was not designed to achieve nor did it achieve effluent perchlorate concentrations less than the 18 µg/l provisional action level. Finally, the previous testing was not designed to document that the treatment process produced potable water.

To further develop the biological reduction process for application in the San Gabriel Basin, a Phase 1 Treatability Study was performed at Aerojet's Sacramento, California facility. This treatability study was performed between November 1997 and May 1998. The results of this study have been documented in *Draft Report, Phase 1 Treatability Study* (HLA 1997a). In summary, the Phase 1 Treatability Study demonstrates that the biological reduction method using GAC/FB technology successfully reduces low concentrations of perchlorate to concentrations below the 4 µg/l laboratory reporting limit. At the same time, concentrations of nitrate were reduced from approximately 10 milligrams per liter (mg/l) (as nitrogen) to less than the laboratory reporting limit of 0.1 mg/l. Additionally, the alternative source of microorganisms used for the biological process also proved to be satisfactory in building the microbial population needed to destroy perchlorate and nitrate. Operation of the Phase 1 system identified operating parameters that can be used to achieve optimum system performance and established operating limits for these parameters. Operational controls (e.g., hydraulic retention time, recycle ratio, ethanol dose, and phosphorus dose) were also evaluated to establish the design criteria necessary to ensure successful treatment operations.

Although a considerable amount of information was obtained from the Phase 1 Treatability Study, several important issues require further evaluation. For the Phase 2 Treatability Study, scale-up factors will be evaluated from the Phase 1 flow (25 gallons per minute [gpm]) to the Phase 2 flow (500 gpm) which can then be used in design of the proposed full-scale system (20,000 gpm). The Phase 1 system was located in Sacramento and used a water source which had similar, but not identical, water quality characteristics than that of San Gabriel Basin groundwater. Therefore, the Phase 2 Pilot System will be located at a site owned by the La Puente Valley County Water District (LPVCWD) in the San Gabriel Basin. Finally, the

Phase 1 treatment system was not designed to produce potable water. The Phase 2 Pilot System will consist of a treatment train identical to the treatment train proposed for the full-scale system and will include all of the unit processes required to produce potable water.

Following issuance of the Draft Phase 2 Treatability Study Work Plan in May 1998, nitrosodimethylamine (NDMA) and 1,4 dioxane were detected in BPOU groundwater. The discovery of NDMA prompted a change in the treatment strategy proposed for the Phase 2 Pilot System and the BPOU full-scale system. NDMA is neither adsorbable nor strippable, but can be effectively destroyed by ultraviolet (UV) irradiation. UV irradiation, with the addition of an oxidizing chemical (e.g., hydrogen peroxide), is also an effective treatment for removal of VOCs and 1,4 dioxane. Therefore, air stripping, which was originally proposed for removal of VOCs, was replaced with UV/oxidation. Liquid-phase granular activated carbon (GAC) contactors were also added for removal of carbon tetrachloride, which is not removed by UV/oxidation.

This revised treatment train offers additional advantages over the previously proposed treatment train. Liquid-phase GAC (located at the end of the treatment train prior to disinfection) will provide a final polishing step and act as a second barrier to any adsorbable compounds. UV/oxidation will provide pathogen destruction prior to the addition of chlorine, will lower the formation potential for disinfection by products (DBPs), and will remove vinyl chloride and other potential byproducts of the biological reduction process.

The purpose of the Phase 2 Treatability Study is to demonstrate that the proposed treatment train will effectively and reliably produce potable water pursuant to all applicable state and federal regulations, optimize the system operating parameters, and collect data for the design and construction of a full-scale treatment facility.

2.0 HISTORY OF PERCHLORATE ISSUES

In February 1997, perchlorate was detected in five drinking water supply wells in Sacramento, California. This discovery was a result of a recent improvement in the analytical method for determining perchlorate analysis that enabled the detection of perchlorate in water at concentrations below the provisional action level (18 µg/l). After the detection of perchlorate in Sacramento water supply wells, DHS performed groundwater sampling and analysis for perchlorate in other portions of the state including the San Gabriel Basin.

2.1 Distribution of Perchlorate in the BPOU

Perchlorate was first detected in San Gabriel Basin groundwater in June 1997 by DHS. This prompted the Main San Gabriel Basin Watermaster (Watermaster) and the BPOUSC to perform additional groundwater sampling and analysis to better understand the distribution of perchlorate in groundwater.

To date, the BPOUSC has compiled perchlorate data for over 50 monitoring wells, production wells, and sampling points in the vicinity of the BPOU. Perchlorate analyses for water supply production wells were performed on samples obtained by the DHS and Watermaster and provided by the San Gabriel Basin Water Quality Authority (SGBWQA). Groundwater samples from monitoring wells in the BPOU were collected by Camp Dresser McKee (CDM), Harding Lawson Associates (HLA), and Geosyntec on behalf of the BPOUSC.

The lateral and vertical distribution of perchlorate in groundwater has been previously described (see *The Distribution and Treatability of Perchlorate in Groundwater, Baldwin Park Operable Unit, San Gabriel Basin* [HLA, 1997b], *Final Addendum to Sampling and Analysis Plan, Pre-Remedial Design Groundwater Monitoring Program, Baldwin Park Operable Unit, San Gabriel Basin* [HLA, 1997c], and *Draft Phase 2A Monitoring Well Installation and Groundwater Sampling Report, Baldwin Park Operable Unit, Pre-Remedial Design Program* [HLA, 1998]). In general, the area that contains concentrations

greater than the DHS provisional action level of 18 µg/l is 5 to 6 miles in length, oriented from northeast to southwest, is approximately 1 mile in width, and up to 800 feet in depth. This approximate perchlorate distribution is based on maximum concentrations detected in any sample or at any depth within a given well.

It should be noted that there is uncertainty regarding the concentrations above the 18 µg/l provisional action level in both the northernmost and southernmost portions of the plume. It should also be noted that there appear to be several sources of perchlorate in the San Gabriel Basin, and that there are anomalous detections in portions of the basin that cannot be explained or that may be the result of laboratory interferences. Therefore, the known perchlorate distribution may change as wells are resampled or as new wells are constructed and sampled.

2.2 Toxicity/Provisional Action Level

In February 1997, the DHS set a provisional action level for perchlorate in groundwater at 4 µg/l, but at that time, laboratory methods were not designed or approved to measure concentrations this low. In May 1997, DHS, based on the results of EPA's recommendations, revised its provisional action level from 4 µg/l to 18 µg/l. DHS stated that it had reevaluated scientific studies in greater detail and had determined that 18 µg/l is consistent with the range of perchlorate exposures the EPA considers protective of human health. DHS requires that water suppliers promptly notify customers whenever perchlorate is present in concentrations greater than 18 µg/l.

In April 1993, the Perchlorate Study Group (PSG) was formed by the U.S. Air Force, various aerospace companies, and the two primary manufacturers of perchlorate compounds. The mission of the PSG was to review and evaluate information on the toxicity of perchlorate and develop better information on what constitutes an acceptable level of perchlorate in soil and groundwater. More recently (1997), the PSG initiated toxicological studies for the purpose of developing a provisional reference dose (RfD) that will

be more reflective of exposure to low levels of perchlorate in water. Results are expected late in 1998 and will be used to calculate a recommended maximum contaminant level (MCL).

3.0 PERCHLORATE TREATMENT BY BIOLOGICAL REDUCTION

Following the detection of perchlorate in groundwater at Aerojet's Sacramento facility, a technology screening, bench-scale studies, and pilot-scale studies were performed by Aerojet and its consultants to address the treatability of perchlorate-contaminated groundwater. This work culminated in the design of a 4,000-gpm treatment system at Aerojet's Rancho Cordova facility that will utilize the process of biological reduction to remove perchlorate from groundwater. This work is described in other documents (HLA 1997a, 1997b, 1998). The proposed Phase 2 Pilot System for the BPOU Consensus Project will utilize the same biological process for perchlorate reduction.

3.1 Conceptual Model of Biological Perchlorate Reduction

The proposed mechanism for biological reduction of perchlorate to chloride, carbon dioxide, and water, with the simultaneous biochemical oxidation of an organic substrate under anoxic conditions, is analogous to that of biological denitrification. Biological denitrification is the reduction of nitrate (NO_3^-) to nitrogen gas (N_2) with the simultaneous biochemical oxidation of an organic substrate under anoxic conditions by facultative microorganisms.

Biological denitrification involves both assimilative and dissimilative nitrate reduction. In the assimilative nitrate reduction process, nitrate is converted to ammonia for use by the cells in biosynthesis and occurs when nitrate is the only form of nitrogen available. In the dissimilative nitrate reduction process, microorganisms oxidize an organic substrate (electron donor) to obtain energy for cell growth and maintenance and utilize nitrate as the electron acceptor (in the absence of oxygen), which is reduced to nitrite (NO_2^-), then to nitric oxide (NO), then to nitrous oxide (N_2O), and finally to nitrogen gas (N_2). Biological denitrification will only occur under anoxic conditions because oxygen is preferred over nitrate as an electron acceptor. The term "anoxic" is used in preference to the term "anaerobic" because the

principle biochemical pathways involved in biological denitrification are not anaerobic but only modifications of aerobic pathways (i.e., nitrate is used as the electron acceptor instead of oxygen).

Using ethanol as the carbon source, nitrate as the nitrogen source and electron acceptor, and assuming that 30 percent of the ethanol is used for cell synthesis and 70 percent for energy conversion (McCarty et al., 1969), the stoichiometry of denitrification can be described by the following empirical equation:



where:

$\text{CH}_3\text{CH}_2\text{OH}$ = Ethanol

$\text{C}_5\text{H}_7\text{O}_2\text{N}$ = Empirical Formula for Cell Mass

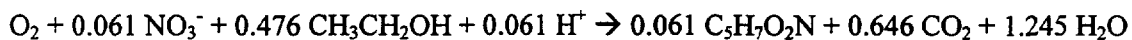
$\text{N: } 1 = 0.071 + 0.929 \quad \checkmark$

$\text{C: } 1.106 = 0.355 + 0.75 \quad \checkmark$

$\text{O: } 3 = 0.553 + 0.464 + 1.5 + 1.91 \quad \checkmark$

This balanced empirical equation indicates that for every mole of nitrate reduced, 0.553 moles of ethanol are consumed. This results in an empirical ethanol requirement of 1.817 milligrams of ethanol per milligram of nitrate-nitrogen reduced. This ethanol requirement applies only to nitrate reduction and does not include other potential electron acceptors such as oxygen and perchlorate.

Using oxygen as the electron acceptor (which is reduced to water), nitrate as the nitrogen source, and ethanol as the carbon source, the stoichiometry can be described by the following empirical equation:



This balanced equation results in an empirical ethanol requirement of 0.685 milligrams of ethanol per milligram of molecular oxygen reduced to water.

The proposed mechanism for reduction of perchlorate (ClO_4^-) is analogous to nitrate reduction except that perchlorate is used as the electron acceptor. Perchlorate is first reduced to chlorate (ClO_3^-), then to

Perchlorate Treatment by Biological Reduction

principle biochemical pathways involved in biological denitrification are not anaerobic but only modifications of aerobic pathways (i.e., nitrate is used as the electron acceptor instead of oxygen).

Using ethanol as the carbon source, nitrate as the nitrogen source and electron acceptor, and assuming that 30 percent of the ethanol is used for cell synthesis and 70 percent for energy conversion (McCarty et al., 1969), the stoichiometry of denitrification can be described by the following empirical equation:



where:

$\text{CH}_3\text{CH}_2\text{OH}$ = Ethanol

$\text{C}_5\text{H}_7\text{O}_2\text{N}$ = Empirical Formula for Cell Mass

$$\text{N: } 1 = .071 + .928 \quad \checkmark$$

$$\text{C: } 1.106 = .955 + .15 \quad \checkmark$$

$$\text{O: } 3 + .553 = .142 + 1.5 + 1.91$$

$$\text{MW} = 24 + 16 + 6 = 46$$

$$\text{MW} = 112 + 17 = 129$$

This balanced empirical equation indicates that for every mole of nitrate reduced, 0.553 moles of ethanol are consumed. This results in an empirical ethanol requirement of 1.817 milligrams of ethanol per milligram of nitrate-nitrogen reduced. This ethanol requirement applies only to nitrate reduction and does not include other potential electron acceptors such as oxygen and perchlorate.

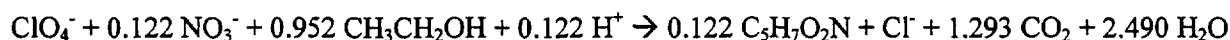
Using oxygen as the electron acceptor (which is reduced to water), nitrate as the nitrogen source, and ethanol as the carbon source, the stoichiometry can be described by the following empirical equation:



This balanced equation results in an empirical ethanol requirement of 0.685 milligrams of ethanol per milligram of molecular oxygen reduced to water.

The proposed mechanism for reduction of perchlorate (ClO_4^-) is analogous to nitrate reduction except that perchlorate is used as the electron acceptor. Perchlorate is first reduced to chlorate (ClO_3^-), then to

chlorite (ClO_2^-), then to hypochlorite (OCl^-), and finally to chloride ion (Cl^-). As in nitrate reduction, ethanol is the carbon source and nitrate is the nitrogen source. The stoichiometry can be described by the following empirical equation:



This balanced equation results in an empirical ethanol requirement of 0.442 milligrams of ethanol per milligram of perchlorate reduced to chloride ion.

The total ethanol requirement can then be computed using the following empirically derived equation:

$$C_e = 1.817 \text{NO}_3^- + 0.685 \text{O}_2 + 0.443 \text{ClO}_4^-$$

where:

C_e = required ethanol concentration (mg/l)
 NO_3^- = initial nitrate-nitrogen concentration (mg/l)
 O_2 = initial dissolved oxygen concentration (mg/l)
 ClO_4^- = initial perchlorate concentration (mg/l)

This equation is slightly conservative in that it assumes that all of the nitrate is consumed by denitrification. A small amount of nitrate is also incorporated into cell mass during oxygen and perchlorate reduction.

This empirical equation illustrates the importance of dissolved oxygen in the reduction of nitrate and perchlorate. Biological contact time and ethanol requirements will both increase as initial dissolved oxygen increases. Both factors will increase capital and operating costs for any treatment process utilizing biological reduction for nitrate or perchlorate removal.

The empirical equations presented in this section provide a good conceptual model for reduction of oxygen, nitrate, and perchlorate. However, the metabolic breakdown of ethanol is a complex process that has been widely studied but has not been completely quantified. There are a variety of classes of organic compounds that are intermediates and potential byproducts of this process, including aldehydes, ketones,

and carboxylic acids. Acetic acid and formic acid are likely intermediates in the acid fermentation of ethanol. Other potential byproducts include acetone, 2-butanone, propionaldehyde, formaldehyde, and acetaldehyde. The potential formation of byproducts and intermediates (other than CO₂ and H₂O) will be addressed in design of the overall treatment scheme. Incomplete oxidation of ethanol may result in a higher required ethanol dosage than predicted by the above empirical equation for total ethanol requirement.

The reduction of oxygen, nitrate, and perchlorate, as presented in this section, are categorized as biologically mediated oxidation-reduction reactions. Given the nature of these reactions, the oxidation-reduction potential (ORP) of the water is an important indicator. A high ORP value indicates an oxidizing environment while a low ORP value (especially negative) indicates a reducing environment. Nitrate and perchlorate reduction require a reducing environment for the reactions to proceed as shown in this section. Once a correlation between ORP and nitrate and perchlorate reduction is established for a given water quality, this correlation can be used to monitor and control a biological reduction system. This approach is feasible with a water source that has a relatively consistent water quality profile, as would be expected from a deep aquifer.

3.2 Phase 1 Treatability Study Results

The Phase 1 Treatability Study results confirmed that nitrate and perchlorate could be effectively removed at concentrations representative of San Gabriel Basin groundwater. When influent dissolved oxygen concentrations were low and adequate ethanol dosages were added, complete destruction of both nitrate and perchlorate were observed. Phase 1 results are discussed in detail in a previous report (HLA, 1997a).

Optimum ethanol dosage was determined to be approximately 40 mg/l for the Phase 1 Treatability Study during the low influent DO period. This concentration is approximately 43 percent higher than predicted

by the empirical ethanol requirement equation developed in the previous section. Optimization of ethanol dosage will continue in the Phase 2 Treatability Study.

ORP data collected during Phase 1 indicated that an ORP of less than approximately -250 millivolts (mV) corresponded to complete nitrate and perchlorate reduction. ORP will continue to be evaluated as a control parameter in the Phase 2 Treatability Study.

3.3 Full-Scale System in Sacramento

Aerojet is in the process of constructing a 4,000 gpm perchlorate treatment system at its Sacramento facility. The system is scheduled to be in operation in November 1998. Although the design flow rate for the system is ultimately planned to be 4,000 gpm, the initial phase will be 2,000 gpm. Four bioreactors will be constructed each with a design flow rate of 1,000 gpm. Each bioreactor will be 14 feet in diameter and 22 feet tall. It is expected that under normal operating conditions, the biomass bed depth will be 15 feet. Effluent will flow through continuous backwash sand filters to remove biomass and particulates.

Performance data from Aerojet's Sacramento treatment unit, along with the Phase 1 Treatability Study results, will be used during design and operation of the Phase 2 Pilot System.

4.0 PHASE 2 OBJECTIVES

The Phase 2 treatability study objectives are to confirm the destruction/removal efficiency of each unit operation in the treatment train and the treated water quality of the entire process, optimize the operating parameters for each unit operation, collect data to support the permitting of the facility as a potable water source, and collect data required for the design and construction of a full-scale treatment system.

4.1 Confirm Destruction/Removal Efficiencies

The primary objective of the Phase 2 treatability study is to confirm the ability of the treatment train to remove or destroy the contaminants of concern and produce treated water that meets drinking water standards. Because each unit operation in the treatment train will be used to treat specific contaminants, the water quality for each unit operation, as well as for the overall system will be tested during the pilot study.

Specific sampling and analysis protocols will be detailed in a Sampling and Analysis Plan (SAP) which will be prepared as part of the Operation and Maintenance (O&M) Manual for the Pilot System.

Individual unit operations and the contaminants to be removed by each system are summarized below:

- **Bioreactor**
 - Nitrate
 - Perchlorate
- **Multimedia Filters**
 - Suspended Solids
 - Ethanol and breakdown products
 - Viruses and Coliform bacteria

- **UV/Chemical Oxidation System**
 - Chlorinated VOCs
 - Nitrosodimethylamine (NDMA)
 - 1,4 dioxane
 - Viruses and Coliform bacteria
- **Liquid Phase Granular Activated Carbon Adsorption System**
 - Carbon Tetrachloride
 - DBP Precursors
- **Disinfection System**
 - Viruses and Coliform Bacteria

4.2 Establish Operating Parameters

A second objective of the Phase 2 treatability study is to collect data to optimize the operation of each unit operation and the treatment system as a whole. This objective will be accomplished by varying the operating conditions for each unit operation and using the readings from local instrumentation and the results of sample collection and analysis to evaluate system response. The optimization will focus on maximizing system throughput and efficiency of unit operations while maintaining treated water quality.

Specific procedures for optimizing each unit operation will be prepared as part of the O&M Manual.

These procedures will include physical parameters such as valve and piping configuration, flow rates, hydraulic loading rates, chemical feed dosages, temperature, pressure, and redox potential, as well as sample collection and analysis to determine performance under the varying conditions. The following is a summary of key operating parameters for each unit operation.

- **Bioreactor**
 - Fluidized bed height
 - Dissolved oxygen profile

- Oxidation/reduction potential (ORP) profile
- Recycle rate
- Mixed liquor suspended solids concentration (MLSS)
- Ethanol dosage
- Phosphorous dosage (if required)
- Mean cell residence time (sludge age)
- Specific utilization rate
- Specific growth rate
- Food to microorganism (F/M) ratio
- **Multimedia Filters**
 - Surface loading rate
 - Pressure drop
 - Polymer dosage
 - Filter cycle time
 - Dissolved oxygen concentration (influent and effluent)
- **UV/Chemical Oxidation System**
 - Residence time
 - UV lamp wattage
 - Hydrogen peroxide dosage
- **Liquid Phase Granular Activated Carbon Adsorption System**
 - Empty bed contact time
 - GAC bed life
 - Pressure drop

- **Disinfection System**
 - Sodium hypochlorite dosage
 - Chlorine contact time
 - Residual chlorine concentration

4.3 Collect Data to Support Permitting as Potable Water Source

Another objective of the Phase 2 Treatability Study is to demonstrate a reliable, stable treatment process and to collect data to support the rigorous application requirements for a permit to operate the Pilot System as a potable water source. Data will also be collected for evaluation of the formation of DBPs; the absence of flocculation and sedimentation in the treatment train will require that the proposed filtration system be certified (The same is true if the proposed filtration rate exceeds 6 gpm/ft², the maximum rate specified in Title 22); the biological inoculum used to seed the growth of biomass will be characterized using plate counts to identify the microorganisms present, particularly human pathogens; and taste, color, and odor, and the potential for biological growth in the distribution system will be addressed.

Specific data collection plans will be prepared for each area and included as part of the SAP for the Pilot System. Input from the appropriate agencies, such as the Department of Health Services Drinking Water Branch, Main San Gabriel Basin Watermaster, and the Metropolitan Water District of Southern California will be solicited during preparation of these plans.

4.4 Collect Data to Support Design of Full-Scale System

The final objective of the Phase 2 Treatability Study is to collect data and practical operating information to support the design, construction, and operation of a full-scale treatment system. The information collected during operation of the Pilot System including analytical data, instrument readings, power consumption data, removal efficiencies, hydraulic loading rates, control logic functionality, and

maintenance requirements will be taken into consideration during the conceptual and detailed design of a full-scale treatment system.

5.0 TREATMENT SYSTEM DESIGN

5.1 Conceptual Design

The treatment train for the Phase 2 Pilot System is designed to progressively remove contaminants from the water using a series of unit operations. The unit operations are sequenced to provide maximum removal efficiencies while minimizing potential interferences with downstream processes. The sequence of treatment operations will enable the Pilot System to meet effluent requirements while minimizing costs and waste production. The treatment train is designed to be a multi-barrier system with respect to both chemical and biological contaminants. The ultimate objective of the Pilot System is to demonstrate the ability of this treatment train to reliably treat the extracted groundwater to provide potable water meeting all applicable state and federal requirements for chemical and biological contaminants, turbidity, color, odor, and residual disinfectant concentration.

5.2 Treatment Unit Processes

The treatment train includes a fluidized bed bioreactor, multimedia filters, UV/oxidation, GAC adsorption, and disinfection. The proposed process flow diagram for the Pilot System is presented in Figure 5.1.

5.2.1 GAC/FB Bioreactor

The GAC/FB bioreactor is designed to remove nitrate and perchlorate under anoxic conditions. The influent groundwater will be fed into the bottom of the reactor through a network of nozzles. The upward velocity of the water will fluidize the GAC media contained in the reactor. The fluidized media provides extensive surface area for growth of microorganisms. Ethanol will be fed into the bioreactor to serve as a carbon source for growth of microorganisms. Dissolved oxygen (DO) in the influent groundwater will be quickly utilized for aerobic breakdown of the ethanol, creating an anoxic condition in the bioreactor. Under these conditions, facultative organisms will utilize nitrogen and perchlorate as electron acceptors

while metabolizing ethanol. Nitrate will be reduced to nitrogen gas, and perchlorate will be reduced to chloride ion.

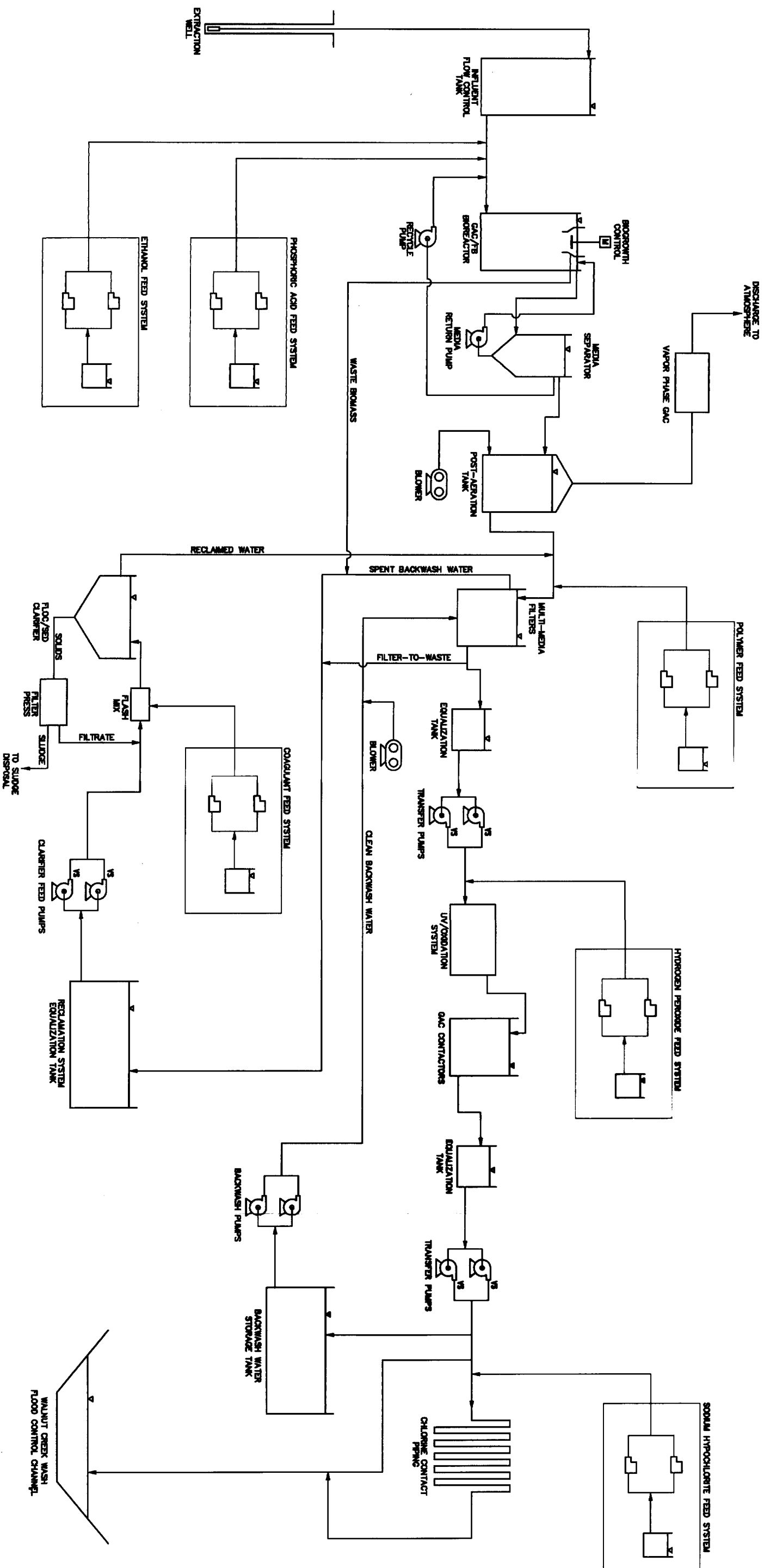
The bioreactor is the first unit operation in the treatment train because nitrate interferes with the UV/chemical oxidation system and the very low DO levels present in the groundwater are conducive to developing anoxic conditions within the reactor. As discussed in Section 3.0, minimizing influent DO concentration also minimizes the contact time required in the bioreactor and reduces the required ethanol dosage.

Following treatment in the bioreactor, a post-aeration tank will be used to raise the DO level in the groundwater to a level (approximately 4 to 5 mg/l) sufficient to maintain aerobic conditions in the multimedia filters, which will be operated in a biologically active mode. In the aeration tank, air will be gently sparged into the water to raise the DO level while minimizing stripping of VOCs. The tank will be covered and will vent through a vapor phase GAC adsorber.

5.2.2 Multimedia Filters

The multimedia filters will remove suspended solids from the bioreactor overflow and will provide biological degradation of residual ethanol and metabolic byproducts not fully removed in the bioreactor. A backwash pump and tank will be activated based on head loss across the filter to backwash individual filters as they become loaded with solids. Two filters will be installed so that system operation can continue during backwash cycles and to provide operational flexibility so that the filtration rate can be optimized during operation of the Pilot System.

The multimedia filters are positioned between the bioreactors and the UV/oxidation system in the treatment train. This positioning allows removal of suspended biomass and GAC fines that could interfere with the performance of the UV/oxidation system, and so that excess ethanol or ethanol breakdown



Explanation

- Main Process Flow
- Reclamation System Flow
- Chemical Addition

- Pump
- Blower
- Chemical Metering Pump
- VS = Variable Speed

products can be biologically degraded before entering the UV/oxidation system and thereby avoid increasing peroxide demand.

5.2.3 UV/oxidation

The UV/oxidation system will oxidize VOCs, chlorinated VOCs, NDMA, and 1,4 dioxane using a combination of ultraviolet (UV) light and hydrogen peroxide. The effectiveness of this technology for destruction of NDMA and 1,4 dioxane, as well as many VOCs and chlorinated VOCs is well documented. The UV light reacts with the hydrogen peroxide to form hydroxyl radicals, which are extremely reactive. The hydroxyl radicals will rapidly react with the contaminants remaining in the groundwater, with the exception of carbon tetrachloride. In general, reaction with UV light, hydrogen peroxide, or hydroxyl radicals will cleave a contaminant molecule into two or more breakdown products which, in turn, react with the oxidants in successive steps to the end products CO_2 , H_2O , and Cl^- .

This system is positioned after the bioreactor and the multimedia filters in the treatment train so that nitrate and suspended solids, which interfere with the UV/oxidation process, are removed from the water before it enters the UV/oxidation system. In addition, the multimedia filters will be biologically active and will remove excess ethanol or ethanol breakdown products upstream of the UV/oxidation system to minimize ancillary consumption of UV light, hydrogen peroxide, and hydroxyl radicals.

5.2.4 Liquid Phase Granular Activated Carbon Adsorption

The Phase 2 Pilot System incorporates liquid phase GAC adsorption to remove carbon tetrachloride from the groundwater. Carbon tetrachloride is the only compound detected in the groundwater that is not amenable to biological or UV/oxidation treatment. GAC is a proven method for removal of carbon tetrachloride. The GAC will also serve as a second barrier for VOCs and chlorinated VOCs in the unlikely event that these compounds are present in the UV/oxidation system effluent.

The GAC system is positioned at the end of the treatment train to maximize the utilization of the destructive unit operations upstream, and to minimize the use of GAC. This approach will minimize the frequency of GAC bed replacement and the associated cost. Placement downstream from the multimedia filters will also protect the GAC adsorbers from fouling due to suspended solids in the groundwater.

5.2.5 Disinfection

The Phase 2 Pilot System will include disinfection for a small portion (5 gpm) of the total flow to establish chlorine dose and required contact time, and quantify the formation of DBPs. The remainder of the flow will be discharged directly to the Walnut Creek Wash Flood Control Channel without disinfection. A full-scale disinfection system will be constructed if a potable water permit is obtained for the system. The disinfection system will utilize sodium hypochlorite to introduce chlorine into the treated water. Disinfection contact time will be provided by a long pipe arranged in a serpentine fashion. A study of the disinfection system will be performed as part of the operation of the Pilot System prior to application for a permit for potable use of the treated water. The study will include quantification of chlorine dose, chlorine contact time, CT_{10} calculation, chlorine residual concentration, and DBP formation in the disinfection system.

5.3 Multi-Barrier Treatment System

The treatment train for the Phase 2 Pilot System is designed to provide a multi-barrier system for both chemical and biological contaminants. For non-chlorinated VOCs, biologically active multimedia filters, UV/oxidation, and GAC provide three distinct barriers. Not all VOCs are equally amenable to the three treatment processes, but the majority are amenable to some degree to all three. For 1,4-dioxane and chlorinated VOCs, with the exception of carbon tetrachloride, the use of UV/oxidation and GAC provide two distinct barriers. While GAC is not an ideal treatment for 1,4-dioxane, it is adsorbable to a degree. Carbon tetrachloride is not effectively treated with UV/oxidation, but can be removed reliably with GAC. Nitrate and perchlorate are essentially treated only in the bioreactor, although perchlorate is slightly

amenable to GAC treatment. The multi-barrier treatment for biological contaminants such as Giardia and cryptosporidium cysts includes removal by filtration in the multimedia filters, deactivation via UV/oxidation, and deactivation in the disinfection system.

5.4 Detailed Design

Detailed design of the treatment system will include sizing of pumps, tanks, piping, and other equipment, selection of materials of construction for piping and equipment, design of concrete structures and foundations, design of power supply and instrumentation and control systems, and a constructability review. The design package will consist of a set of detailed drawings and specifications, and a detailed construction schedule. The design documents will be provided to the appropriate regulatory agencies for review. A preliminary list of drawings and specifications to be prepared during detailed design is provided in Appendix A.

6.0 TREATMENT EQUIPMENT DESCRIPTION

This section presents preliminary design criteria and descriptions for each unit process in the Phase 2 Pilot System treatment train including the extraction well, influent equalization tank, GAC/FB bioreactor, multimedia filters, UV/oxidation system, GAC contactors, disinfection system, and flow equalization tanks and transfer pumps. Preliminary design criteria for each unit process are presented in Table 6.1. Final design criteria will be developed during detailed design of the Pilot System. Anticipated influent water quality for the Pilot System is presented in Table 6.2.

6.1 Extraction Well

The LPVCWD Well No. 2 will be used as the extraction well for the Pilot System. This well is located on the same property as the proposed location of the Pilot System. The pump installed in Well No. 2 can be operated at flow rates ranging from 500 to 1,200 gpm. The design flow rate for the Pilot System will be 500 gpm.

6.2 Influent Flow Control Tank

The extraction well will pump water to a 15,000 gallon influent flow control tank. The tank will be equipped with level sensors to control the flow from the variable speed well pump. The water level in the tank will be set to provide gravity flow at a constant rate through the bioreactor and multimedia filters. Based on manufacturer recommendations, reverse flow in the bioreactor should be avoided to prevent GAC fines from clogging the distribution nozzles. Gravity flow, combined with an automatic shutoff valve between the flow control tank and the bioreactor, will ensure that flow in the bioreactor will not reverse. The influent flow control tank will be constructed of either concrete or steel.

6.3 GAC/FB Bioreactors

One GAC/FB bioreactor will be constructed to reduce nitrate and perchlorate concentrations. The reactor has been preliminarily sized at 10.5-feet by 10.5-feet square and approximately 22 feet tall. The reactor

Treatment Equipment Description

will utilize a fluidized bed depth of 15 feet based on the Phase I Treatability Study. Recycle percentages ranging from 0 percent to 100 percent and surface overflow rates ranging from 6 to 10 gpm/ft² will be evaluated during pilot testing. The optimum recycle ratio will be assessed first and used to calculate the optimum surface overflow rate. Empty bed contact time (EBCT) will range from 11 to 19 minutes depending on the surface overflow rate. Bioreactor performance will be based primarily on influent and effluent nitrate and perchlorate concentrations and turbidity. Operating parameters such as recycle ratio, pH, ORP, DO, TOC, and MLSS will also be monitored and biological growth parameters such as mean cell residence time (sludge age), specific utilization rate, specific growth rate, and F/M ratio will be evaluated. The bioreactor will be constructed of concrete.

A biogrowth control system will be used to control the fluidized bed depth and the amount of biomass in the reactor. As biomass accumulates on the GAC particles, the fluidized bed height will increase. To control the fluidized bed level, the biogrowth control system, consisting of a growth control cone and a submersible centrifugal pump set at the desired level, will shear excess biomass from the GAC. Buoyant biomass-coated GAC will collect in the growth control cone and be pulled into the suction port on the centrifugal pump. The pumping action will shear excess biomass, and both the sheared biomass and the "clean" GAC particles will be returned to the growth control cone. The "clean" GAC, which is less buoyant than the biomass-coated GAC, will sink toward the bottom of the reactor to provide growth sites for new biomass. The sheared biomass will float to the top of the growth control cone and will flow by gravity to a separate biomass waste line. The waste biomass will be discharged to the reclamation system holding tank for treatment in the reclamation system. Collecting waste biomass separately will result in a less turbid reactor effluent and extend the multimedia filter run time.

Ethanol and phosphoric acid (if needed) will be added to the groundwater upstream of the bioreactor. The ethanol feed system has been preliminarily sized to provide a maximum dosage of 30 mg/l based on the Phase 1 Treatability Study and stoichiometric estimates. A redox probe installed in the bioreactor effluent

Table 6.1: Preliminary Pilot System Design Criteria

Description	Value	Unit
Extraction Well		
Description: LPVCWD Well No. 2		
Flow Rate	500	gpm
Influent Flow Control Tank		
Holding Time	30	minutes
Volume	15,000	gal
GAC/FB Bioreactor		
<i>Bioreactor</i>		
Recycle Ratio (Recycle Flow : Influent Flow)	0.50	
Total Bioreactor Flow Rate	750	gpm
Overflow Rate	7	gpm/ft ²
Number of Reactors	1	
Surface Area/Reactor	107.1	ft ²
Width & Length	10.4	ft
Fluidized Bed Depth	15	ft
Fluidized Bed Volume	1,607	ft ³
Empty Bed Contact Time	16.0	minutes
Sludge Yield Factor (by weight)	0.8	VSS/NO ₃ ⁻ -N
Nitrate-N Influent Concentration	6	mg/l
Biological Solids Production (as VSS)	28.8	lb/day
<i>Ethanol Feed System</i>		
Ethanol Dose	30	mg/l
Mass Loading	180	lb/day
Ethanol Density	6.67	lb/gal
Volumetric Loading	27	gal/day
Feed Tank Holding Time	15	days
Feed Tank Volume	405	gal
Total Number of Feed Pumps	2	
Number of Feed Pumps Operating	1	
Feed Pump Flow Rate	27	gal/day

Table 6.1 (continued)

Description	Value	Unit
<i>Phosphoric Acid Feed System</i>		
Phosphoric Acid Dose (as H_3PO_4)	1	mg/l
Phosphorous Dose (as P)	0.32	mg/l
Mass Loading	6	lb/day
Percent Phosphoric Acid by Weight	50%	
Phosphoric Acid (85%) Density	14.1	lb/gal
Volumetric Loading	0.85	gal/day
Feed Tank Holding Time	30	days
Feed Tank Volume	26	gal
Total Number of Feed Pumps	2	
Number of Feed Pumps Operating	1	
Feed Pump Flow Rate	0.85	gal/day
<i>Biomass Control System</i>		
Biomass Growth Control Cone		
Submersible Centrifugal Pump		
Waste Biomass Collection and Discharge		
<i>Post Aeration Basin</i>		
Oxygen Dose	5	mg/l
Mass Oxygen Loading	30.0	lb/day
Oxygen Transfer per Diffuser Unit	1.5	lb/day
Number of Diffuser Units	20	
Diffuser Spacing	12	inches
Aeration Basin Length and Width	6.5	ft

Table 6.1 (continued)

Description	Value	Unit
Multimedia Filters		
<i>Filters</i>		
Type: Declining Rate or Constant Rate		
Loading Rate	4	gpm/ft ²
Number of Filters	2	
Surface Area/Filter	62.5	ft ²
Width & Length	7.9	ft
Anthracite Layer Depth	16	in
Sand Layer Depth	10	in
Garnet Layer Depth	4	in
Overall Bed Depth	2.5	ft
<i>Polymer Feed System</i>		
Polymer Dose	1	mg/l
Mass Loading	6.00	lbs/day
Hopper Holding Time	31	days
Hopper Size	186	lbs
Mix Ratio by Weight	1%	
Volumetric Loading Rate	72	gal/day
Mix/Feed Tank Holding Time	15	days
Mix/Feed Tank Volume	1080	gal
Total Number of Feed Pumps	2	
Number of Feed Pumps Operating	1	
Feed Pump Flow Rate	72	gal/day
<i>Backwash System</i>		
Type: Combined Air and Water		
Water Overflow Rate	10	gpm/ft ²
Air Flow Rate	3	cfm/ft ²
Backwash Flow Rate	625	gpm
Total Number of Backwash Pumps	2	
Number of Backwash Pumps Operating	1	
Backwash Pump Flow Rate	625	gpm
Backwash Time/Filter	15	minutes
Backwash Volume/Filter	9,375	gal
Backwash Frequency/Filter	1	days
Clean Backwash Water Storage Tank Volume (1 Filter + 30%)	12,188	gal
Filter-to-Waste Time/Filter	10	minutes
Filter-to-Waste Volume/Filter	2,500	gal

Table 6.1 (continued)

Description	Value	Unit
UV/Oxidation System		
<i>UV/Oxidation System</i>		
Number of Units	1	
Number of Lamps (30 kW each)	3	
Total UV Power	90 kW	
<i>Peroxide Feed System</i>		
Peroxide Dose	10 mg/l	
Mass Loading	60 lb/day	
Percent Peroxide by Weight	50%	
Peroxide (50%) Density	8.34 lb/gal	
Volumetric Loading	14 gal/day	
Feed Tank Holding Time	15 days	
Feed Tank Volume	216 gal	
Total Number of Feed Pumps	2	
Number of Feed Pumps Operating	1	
Feed Pump Flow Rate	14 gal/day	
GAC Contactors		
<i>Contactors</i>		
Loading Rate	5 gpm/ft ²	
Total Number of Contactor Trains (1 Train = 2 Contactors in Series)	1	
Number of Contactor Trains Operating	1	
Surface Area/Contactor	100.0 ft ²	
Width & Length	10.0 ft	
Weight of GAC/Contactor	20,000 lbs	
Density of GAC	30 lb/ft ³	
Volume of GAC/Contactor	667 ft ³	
GAC Bed Depth	6.7 ft	
Empty Bed Contact Time	10 minutes	
Estimated Bed Life (based on 5 ug/l CCl ₄)	500 days	

Table 6.1 (continued)

Description	Value	Unit
Disinfection System		
<i>Sodium Hypochlorite Feed System</i>		
Disinfection System Flow Rate	5	gpm
Chlorine Dose	3	mg/l
Chlorine Mass Loading	0.2	lb/day
Available Chlorine	1.0%	
Sodium Hypochlorite Mass Loading	18.0	lb/day
Sodium Hypochlorite Density	8.34	lb/gal
Sodium Hypochlorite Volumetric Loading	2.2	gal/day
Feed Tank Holding Time	7	days
Feed Tank Volume	15	gal
Number of Feed Pumps	1	
Feed Pump Flow Rate	2.16	gal/day
<i>Chlorine Contact Piping</i>		
Pipe Diameter	4	inches
Velocity	0.13	ft/s
Contact Time	20	minutes
Pipe Length	154	feet
Reclamation System		
<i>Reclamation System Equalization Tank</i>		
Equalization Tank Volume (2 Filter Backwash Volumes)	18,750	gallons
<i>Feed Pumps</i>		
Average Flow to Reclamation System	41.5	gpm
Total Number of Feed Pumps	2	
Number of Feed Pumps Operating	1	
Feed Pump Flow Rate	41.5	gpm
<i>Coagulant Feed System</i>		
Options: Ferric Chloride, Ferric Sulfate, Aluminum Sulfate		
Coagulant Dose	30	mg/l
Mass Loading	14.9	lb/day

Table 6.1 (continued)

Description	Value	Unit
<i>Clarifier</i>		
Type: Flocculation/Sedimentation		
Overflow Rate	0.5	gpm/ft ²
Number of Clarifiers	1	
Surface Area/Clarifier	83.0	ft ²
Clarifier Diameter	10.3	ft
Total Dry Solids Production (Biological + Coagulant)	43.8	lb/day
Clarifier Sludge Percent Solids	2%	
Clarifier Sludge Production	4,392	gal/day
<i>Filter Press</i>		
Type: Plate and Frame		
Filter Cycle Time	3	hrs
Filter Operation	21	hrs/day
Filter Cycles per Day	7	cycles/day
Filter Press Volume	84	ft ³
Filter Sludge Percent Solids	40%	
Filter Sludge Production (as wet solids)	109	lbs/day
Flow Equalization Tanks and Transfer Pumps		
<i>Equalization Tanks</i>		
Tank Holding Time	30	minutes
Tank Volume	15,000	gal
<i>Transfer Pumps</i>		
Type: Variable Speed		
Total Number of Pumps	3	
Number of Pumps Operating	2	
Pump Flow Rate	250	gpm

Table 6.2: Anticipated Pilot System Influent Water Quality

Analyte	Value
VOCs	
Trichloroethylene (1,1,2-trichloroethene)	67.8
1,2-dichloroethane (ethylene dichloride)	5.0
Carbon tetrachloride (tetrachloromethane)	3.9
Tetrachloroethene (perchloroethylene)	3.5
Dichlorodifluoromethane (fluorocarbon-12)	2.8
Chloroform (trichloromethane)	2.7
cis-1,2-dichloroethylene	1.2
1,1-dichloroethylene	0.6
Total VOCs	87.5
Other Analytes	
Nitrate-N (mg/l)	5.6
Perchlorate	141.5
N-nitrosodimethylamine (NDMA)	0.9
1,4-dioxane	1.5
Total trihalomethanes (TTHM)	2.5

All values in micrograms per liter ($\mu\text{g/l}$) unless otherwise noted
Sampling results from LPVCWD Wells 02 and 03
Values are average for samples taken on 2/6/98 and 6/11/98
Only analytes with concentrations above detection limit shown
All other analytes tested had concentrations below detection limit

line will supply input to a controller that will be used to adjust the ethanol dosage. The redox controller output will be adjusted during pilot testing based on minimizing the effluent ethanol concentration while still achieving required perchlorate and nitrate removals. The phosphoric acid feed system has been preliminarily sized to provide a maximum phosphorous dosage of 0.3 mg/l. Optimum phosphorous dosage will be determined during pilot testing according to residual phosphorous concentrations in the bioreactor effluent.

Biological solids production is preliminarily estimated based on a sludge yield factor of 0.8 mg of volatile suspended solids (VSS) created per mg of nitrate-nitrogen reduced in the bioreactor (Metcalf & Eddy, 1991). Assuming an influent nitrate-nitrogen concentration of 6 mg/l, approximately 29 pounds of VSS will be produced per day. The VSS will be transported to the reclamation system via the biomass waste line, in the filter backwash water, or in the filter-to-waste water.

Oxygen will be added to the bioreactor effluent in a post-aeration basin upstream of the multimedia filters, which will be operated in a biologically active mode. This will allow the biomass in the filters to consume remaining ethanol and breakdown products in the bioreactor effluent. The basin is preliminarily sized to increase the DO concentration from 0 mg/l to approximately 5 mg/l using fine bubble diffusers. The oxygen demand in the bioreactor effluent is expected to be less than 1 mg/l. Optimum DO concentration will be assessed during pilot testing. While the main objective of the post-aeration basin is to add oxygen, some stripping of VOCs may take place. Therefore, the discharge air from the basin will be collected in a hood and passed through a vapor-phase GAC contactor. During pilot testing, operation of the post-aeration basin will be adjusted to minimize the amount of VOC stripping that occurs.

6.4 Multimedia Filters

Two multimedia filters will be constructed to filter the bioreactor effluent and consume any remaining ethanol. The filters have been preliminarily sized at 8-feet by 8-feet square and approximately 12 feet tall. The bed will consist of anthracite, sand and garnet with a total bed depth of 2.5 feet. Surface loading rates

ranging from 4 to 8 gpm/ft² will be evaluated during pilot testing. If a loading rate greater than 6 gpm/ft² proves to be optimum, approval of the higher loading rate will be sought pursuant to Title 22 regulations. Effluent turbidity (via inline turbidimeters), pathogen removal, and effluent ethanol concentration will be used to evaluate filter performance. Filtered water quality will also be evaluated using particle analyzers. The filters will be designed to accommodate both declining-rate and constant-rate loading and each type will be evaluated during pilot testing to determine which is better suited to the treatment process. The multimedia filters will be constructed of concrete.

Polymer will be added prior to the multimedia filters as a filter aid. The polymer feed system has been preliminarily sized for a maximum dosage of 1 mg/l. Optimum polymer dosage will be assessed during pilot testing. The polymer will be mixed using an inline static mixer to promote coagulation. The need for flocculation is not anticipated for this application to meet the Title 22 requirements. Results from the pilot testing will be used to demonstrate that this treatment train meets the Title 22 performance standards for filtration.

The multimedia filters will be backwashed using a combination of air and water. The backwash system has been preliminarily sized to provide 15 minutes of continuous backwash using a water overflow rate of 10 gpm/ft² and an air flow rate of 3 standard cubic feet per minute per square foot (scfm/ft²). Filter run times have been preliminarily estimated to be at least 24 hours. Actual filter run time will be determined during pilot testing based on head loss across the filter. Clean backwash water will be collected from the main process stream at a point prior to disinfection and stored in a separate holding tank. Collecting clean backwash water prior to disinfection is required to ensure that the filters remain biologically active. Spent backwash water will be discharged to the reclamation system holding tank for treatment in the reclamation system.

A filter-to-waste system will be utilized following each filter backwash. Filter effluent for the first 10 minutes of each filter run will be discharged to the reclamation system holding tank for treatment in the reclamation system. Optimum filter-to-waste time will be determined during pilot testing based on measurement of filter effluent turbidity following backwash.

6.5 UV/oxidation System

One UV/oxidation System will be installed to remove VOCs, NDMA, and 1,4-dioxane. The UV system has been preliminarily sized to provide a total of 90 kilowatts (kW) of UV power, or 3 lamps at 30 kW each, based on anticipated influent concentrations of VOCs, NDMA, and 1,4-dioxane. The UV unit will be sized to house up to 5 lamps. Optimum UV power will be determined during pilot testing. Influent and effluent concentrations of VOCs, NDMA, and 1,4-dioxane will be used to evaluate the UV/oxidation system performance.

Hydrogen peroxide will be used as the oxidant for the UV system and injected prior to the UV unit. The hydrogen peroxide feed system has been preliminarily sized for a dosage of 10 mg/l. Optimum dosage will be determined during pilot testing.

6.6 GAC Contactors

Two GAC contactors (operated in series) will be installed to remove carbon tetrachloride and act as a final polishing unit. The GAC contactors have been preliminarily sized for a surface loading rate of 5 gpm/ft², resulting in a 10-foot by 10-foot square contactor approximately 12 feet tall. Each contactor will contain approximately 20,000 lbs of GAC with a bed depth of 7 feet and have an EBCT of 10 minutes (20 minutes total for two contactors in series). The GAC bed life has been preliminarily estimated at 500 to 700 days based on the expected carbon tetrachloride concentration. The GAC contactors will be constructed of concrete with stainless steel distribution piping.

6.7 Disinfection System

Sodium hypochlorite will be used as the disinfectant for the Pilot System and injected into the GAC effluent, routed through a long pipe arranged in a serpentine fashion to provide contact time, and discharged to the Walnut Creek Wash Flood Control Channel adjacent to the site. During pilot testing, only a portion of the flow (5 gpm) will be disinfected. A disinfection system capable of treating the full flow will be constructed if a potable water permit is obtained for the system. The sodium hypochlorite feed system has been preliminarily sized for a chlorine dose of 3 mg/l. Optimum chlorine dose will be determined during pilot testing based on residual chlorine concentration. Formation of DBPs will also be monitored during pilot testing.

6.8 Reclamation System

A reclamation system will be constructed to treat backwash water and filter-to-waste water from the multimedia filters and waste biomass from the GAC/FB bioreactors. The reclamation system will include coagulation followed by a flocculation/sedimentation clarifier. Average flow to the reclamation system has been preliminarily estimated at 41 gpm based on filter backwash and filter-to-waste assumptions and assuming that 5 percent of the bioreactor flow is discharged as waste biomass. The clarifier has been preliminarily sized for a surface overflow rate of 0.5 gpm/ft², resulting in a 10-foot-diameter clarifier. A tube settler will also be evaluated in place of the flocculation/sedimentation clarifier during final design. Reclaimed water will be returned to the main flow stream prior to the multimedia filters.

Ferric chloride, ferric sulfate and aluminum sulfate (alum) will be evaluated as coagulants for the reclamation system. Coagulant dose is preliminarily estimated at 30 mg/l, approximately 50% (by weight) of the biological solids production. The optimum coagulant and coagulant dose will be determined during pilot testing.

Clarifier solids production is preliminarily estimated at approximately 44 pounds of dry solids per day based on biological solids production and coagulant dose. Based on an estimated clarifier sludge solids content of 2 percent, approximately 4,400 gallons of clarifier solids will be produced per day. A filter press will be used to further concentrate the clarifier sludge to approximately 40 percent solids. This will result in approximately 110 pounds of wet sludge produced per day. This sludge will be disposed off-site at an appropriate land disposal facility.

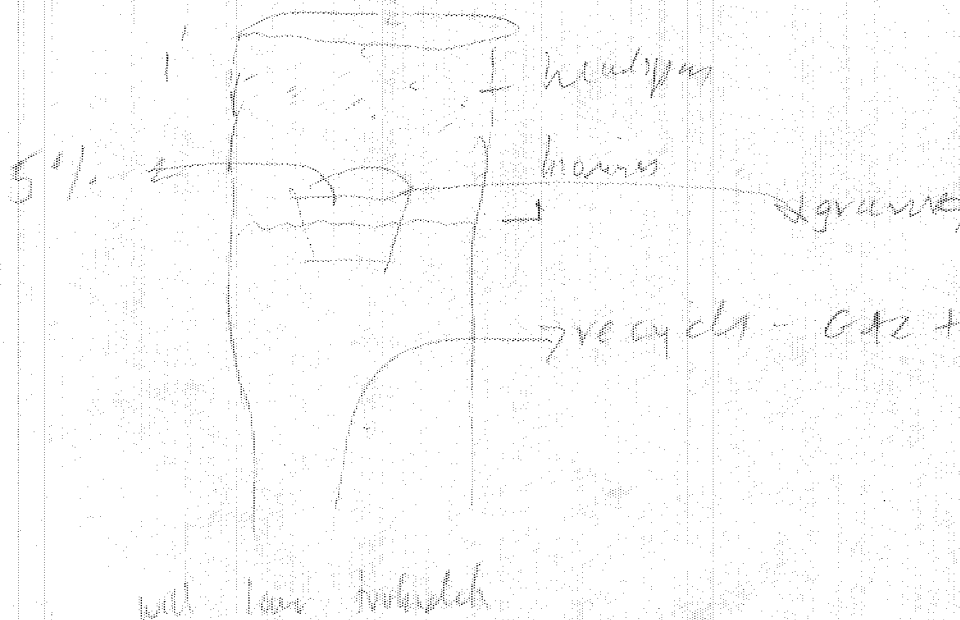
6.9 Flow Equalization Tanks and Transfer Pumps

Flow equalization will be required at two locations in the treatment train; between the multimedia filters and UV/oxidation system, and between the GAC contactors and the disinfection system. The tanks have been preliminarily sized for a holding time of 15 minutes, resulting in a tank volume of 15,000 gallons. Two variable speed, centrifugal transfer pumps will be used to transfer water from each equalization tank to the next downstream treatment unit. Level sensors and controllers in the equalization tanks will be used to control the variable speed drives.

Clarifier solids production is preliminarily estimated at approximately 44 pounds of dry solids per day based on biological solids production and coagulant dose. Based on an estimated clarifier sludge solids content of 2 percent, approximately 4,400 gallons of clarifier solids will be produced per day. A filter press will be used to further concentrate the clarifier sludge to approximately 40 percent solids. This will result in approximately 110 pounds of wet sludge produced per day. This sludge will be disposed off-site at an appropriate land disposal facility.

6.9 Flow Equalization Tanks and Transfer Pumps

Flow equalization will be required at two locations in the treatment train; between the multimedia filters and UV/oxidation system, and between the GAC contactors and the disinfection system. The tanks have been preliminarily sized for a holding time of 15 minutes, resulting in a tank volume of 15,000 gallons. Two variable speed, centrifugal transfer pumps will be used to transfer water from each equalization tank to the next downstream treatment unit. Level sensors and controllers in the equalization tanks will be used to control the variable speed drives.



7.0 PERMITTING

A number of permits must be obtained to build and operate the Phase 2 Pilot System. Some of these permits must be secured prior to start of construction, others are needed before system startup, and others are needed before the system effluent can be introduced into the potable water supply. Some of the key permitting requirements are described below.

7.1 Construction Permits

All construction permits normally required from state and local agencies will be obtained once facility design has been completed.

7.2 Discharge Permit

The Phase 2 Pilot System will discharge treated water to the Walnut Creek Wash Flood Control Channel adjacent to the site. The LPVCWD already has a Walnut Creek discharge point and the Watermaster holds a discharge permit. The Watermaster will amend this permit or obtain a new permit from the Los Angeles Regional Water Quality Control Board for discharge of treated water from the Pilot System. The permitting process has been initiated. The modified discharge permit must be secured before system startup.

7.3 Ethanol Permit

To secure denatured alcohol in the volumes required to support bioreactor operation, a permit from Alcohol, Tobacco, and Firearms (ATF) is required. The permit application has been submitted to ATF. This permit must be secured before system startup.

7.4 Certification of Additives

All chemicals used in a public water supply must be produced by a manufacturer certified to produce those chemicals or be "food grade". All proposed additives for the pilot system appear to be available in food grade. If certification is necessary, two entities can perform this certification: Underwriters

Laboratories (UL) and the National Sanitation Foundation (NSF). Initial chemical sourcing and certification procedures have been initiated. This permit will not be needed until a potable water operating permit is obtained from DHS and treated water is introduced to the potable water supply.

7.5 DHS Operating Permit

An operating permit must be obtained from DHS in order for the Phase 2 Pilot System to introduce water into the potable water supply. Securing this permit is the ultimate goal for the Phase 2 Pilot System and many of the planned activities, monitoring, and data interpretation will be performed to establish the level of confidence necessary for DHS to issue an operating permit for this facility.

The source of water used for the Phase 2 Pilot System (BPOU groundwater) is considered an Extremely Impaired Source by DHS due to the contaminants present in the water and their concentrations. As outlined in the DHS Policy Memo 97-005, "Policy Guidance for Direct Domestic Use of Extremely Impaired Sources", the following elements are required for evaluation of an operating permit:

- Source water assessment including:
 - Delineation of the source water capture zone
 - Identification of contaminant sources
- Full characterization of the raw water quality including:
 - Title 22 drinking water regulated and unregulated chemicals
 - All chemicals for which drinking water action levels are established
 - All chemicals listed pursuant to the Safe Drinking Water and Toxic Enforcement Act of 1986
 - Microbiological quality
 - Priority pollutants
 - Gross contaminant measures [total organic carbon (TOC), etc.]
 - Any compounds identified under source water assessment

- Variability of contaminant concentrations with time (seasonal and long term)
 - Variability of contaminant concentrations with pumping rate
 - Inclusion of any contaminant identified during characterization in the source water assessment
- Source protection program including:
 - Prevention of rising contaminant levels
 - Minimization of dependence on treatment
- Effective monitoring and treatment including:
 - Performance standards
 - Operations plan
 - Reliability features
 - Compliance monitoring and reporting program
 - Notification plan
 - Extremely impaired source water quality surveillance plan
- Human health risks associated with failure of proposed treatment including:
 - Evaluation of the risks of failure of the propose treatment system
 - Assessment of the potential health risks associated with failure of the proposed treatment system
- Identification of alternatives to the use of the extremely impaired source including:
 - Comparison of potential health risk associated with alternative sources to proposed source
 - Comparison of the risks of treatment failure for the alternative sources to proposed source
 - Completion of the California Environmental Quality Act (CEQA) review of the project
 - Submittal of the permit application
 - Public hearing
 - DHS evaluation

The following two findings are required for DHS to approve the use of an extremely impaired source:

- Drinking water MCLs and Action Levels (ALs) will not be exceeded if the permit is complied with
- The potential for human health risk is minimized, and the risk associated with the project is less than or equal to the alternatives

Each of the above elements will be prepared during operation of the Phase 2 Pilot System and a permit application will be submitted to DHS at the conclusion of the Phase 2 Treatability Study.

8.0 OPERATION AND MAINTENANCE MANUAL

Prior to startup of the Pilot System, an O&M manual will be prepared. The O&M manual will contain the following elements:

- Detailed description of each individual process within the overall treatment system, including major equipment components, associated instrumentation and controls, and relationships with the other processes.
- Detailed instructions for operation of each unit operation within the Pilot System, including startup, routine and emergency operations, shutdown, troubleshooting, and general maintenance.
- A description of the control system operation, configuration of graphical interface screens, and instructions for acknowledging alarms and setting system parameters.
- Sampling and Analysis Plan (SAP) described below.
- Record-keeping requirements.
- Health and safety plan (HSP) which describes physical and chemical hazards, requirements for protective clothing, sign-in procedures, emergency response procedures, and contains material safety data sheets (MSDSs) for all chemicals stored onsite. This document will govern all activities at the site during startup and operations and will apply to all personnel working on or visiting the site.
- Compendium of product literature, including manufacturer's installation, operating, and maintenance instructions for all major equipment, and data sheets for all instruments.

The SAP will include:

- Detailed sampling procedures for each category of analytes.
- Location and frequency of sample collection.
- Analytes and analytical methods for each sample.
- Development of focused sampling programs for specific objectives including: study of DBP formation; demonstration of the efficacy of an alternative filtration technology under the surface water treatment rule; development of criteria for "steady state" operation of the bioreactor; study of the potential for biological regrowth in the distribution system; and confirmation of acceptable taste, color, and odor of the product water.
- Development of acceptable analytical methods and detection limits for analytes such as ethanol and carboxylic acids.

- Quality Assurance Project Plan (QAPP) which will include development of data quality objectives (DQOs) and will specify the type and frequency of quality control samples such as blanks and duplicates.

A preliminary list of analytes and analytical methods is provided in Table 8-1. A preliminary table of contents for the O&M Manual is provided below.

OPERATION AND MAINTENANCE MANUAL
Baldwin Park Operable Unit
Pilot Scale Groundwater Treatment System

Preliminary Table of Contents

<u>Chapter</u>	<u>Title</u>
1.0	Introduction
2.0	Permits and Standards
3.0	Description, Operation, and Control
	3.1 Groundwater Extraction System
	3.2 Equalization and Pumping System
	3.3 GAC/FB Bioreactor System
	3.4 Post-Aeration System with Vapor-Phase VAC
	3.5 Chemical Addition Systems
	3.6 Multimedia Filtration System
	3.7 UV/ Oxidation System
	3.8 Granulated Activated Carbon Adsorption System
	3.9 Disinfection System
4.0	Control System and Operator Interface
5.0	Maintenance
6.0	Records
7.0	Process and Instrumentation Drawings
8.0	Health and Safety Plan
9.0	Sampling and Analysis Plan

Appendixes

Appendix A	Discharge Permit
Appendix B	Manufacturer's Operation and Maintenance Instructions
	Equipment
	Instrumentation
	Electrical Hardware
	Control Panel

Table 8-1: Preliminary Summary of Analytes and Methods

Analytes	EPA Method	Preservative	Holding Time	Sample Container	Sample Volume	Method Detection Limit	Reporting Limit
Primary and Secondary Title 22 Analytes	Varied	Varied	Varied	Varied	Varied	Varied	Varied
Volatile Organic Compounds, DBPs, 1,4-Dioxane, Acetone, Methyl Ethyl Ketone	8260	HCL-pH<2	14 days	40 ml VOA	3 x 40 ml	Varied	5 - 100 µg/l
Ethanol, Formaldehyde, Acetaldehyde	8015 (modified)	4°C	14 days	40 ml VOA	1 x 40 ml	To be determined	
Formic Acid, Propionic Acid	GC/MS	HCl ~pH<2	14 days	40 ml VOA	3 x 40 ml	To be determined	
Perchlorate	300 (modified)	4°C	14 days	Poly	125 ml	2 ppb	5 ppb
Chlorate, Chlorite, Hypochlorite	300	4°C	14 days	Poly	100 ml	To be determined	200,20,50 ppb
Nitrosodimethylamine	8270	4°C	14 days	1L Amber	1,000 ml	To be determined	
Alkalinity (carbonate/bicarbonate)	310.1	4°C	14 days	Poly	500 ml	---	5 mg/l ppm
Chloride	325.2	4°C	28 days	Poly	50 ml	0.72 ppb	1.0 mg/l ppm
Total Phosphorus	365.5	H ₂ SO ₄	28 days	Poly	100 ml	0.04 ppb	0.3 mg/l ppm
Nitrogen, Ammonia	350.1	H ₂ SO ₄	28 days	Poly	100 ml	0.027 ppb	0.1 mg/l ppm
Nitrogen, Nitrate, Nitrite	353.1	4°C	28 days	Poly	100 ml	0.0044 ppb	0.1 mg/l ppm
Sulfate, Sulfide	375.4	Cool 4°C	Sulfate - 28 days Sulfide - 7 days	Poly	100 ml	---	1.0 mg/l ppm
Metals*	6000/7000	HNO ₂ - pH<2	6 months	Poly	500 ml	Varied	Varied
Bacteriology [#]	9200	Sodium Thiosulfate 4°C	24 hours	Plastic	100 ml	Varied	Varied
Giardia and Cryptosporidium	IFA/1622						
Viruses							
Total Dissolved Solids	160.1	4°C	7 days	Poly	100 ml	---	10 mg/l ppm
Total Suspended Solids	160.2	4°C	7 days	Poly	500 ml	---	5 mg/l ppm
Turbidity	180.1	4°C	2 days	Poly	50 ml	---	1 NTU
Color	110.2	4°C	2 days	Poly	500 ml		
Total Organic Carbon	9060	4°C	2 days	1L Amber	1,000 ml		
AOC/BDOC							
Biochemical Oxygen Demand	405.1	4°C	2 days	1L Amber	1,000 ml	---	3.0 mg/l
Chemical Oxygen Demand	410.4	HNO ₂ - pH<2	28 days	Poly	50 ml	8.9 ppb	10 mg/L
UV254 Absorption							

µg/l Micrograms per liter
 mg/l Milligrams per liter
 ml Milliliter
 Poly Polyethylene

Table 8-1 (continued)

ppb Parts per billion
ppm Parts per million
VOA Volatile organic analyte
IFA Indirect fluorescent antibody test
AOC Assimilable organic carbon
BDOC Biodegradable organic carbon

* Title 22 metals, potassium, sodium, magnesium, iron, calcium, manganese
Total and fecal coliform and heterotrophic plate count

9.0 REFERENCES

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McCarty, P.L., L. Beck, and P. St. Amant. 1969. Biological denitrification of wastewaters by addition of organic materials. *Proceedings of the 24th Purdue Industrial Waste Conference*, Lafayette, Indiana.

Metcalf & Eddy. 1991. *Wastewater Engineering*. 3rd Ed. McGraw Hill

Appendix A

PRELIMINARY DRAWING LIST
AND
PRELIMINARY LIST OF SPECIFICATIONS

PRELIMINARY DRAWING LIST

GENERAL

Cover Sheet (Title, Maps, Drawing Index, Contacts)
Abbreviations
Drawing Reference and Identification System

CIVIL

Civil Symbols, Linetypes, and General Notes
General Site Plan
Enlarged Site Plan 1
Enlarged Site Plan 2
Enlarged Site Plan 3
Enlarged Site Plan 4
Fence Elevations and Details
Miscellaneous Details
Miscellaneous Details

STRUCTURAL

Equalization Tank Plan
Equalization Tank Sections
Equalization Tank Details
Equalization Tank Details
Bioreactor Plan
Bioreactor Sections
Bioreactor Details
Bioreactor Details
Post Aeration Tank Plan
Post Aeration Tank Sections
Post Aeration Tank Details
Multimedia Filter Plan
Multimedia Filter Sections
Multimedia Filter Sections
Multimedia Filter Details
Multimedia Filter Details
Filter Effluent Tank Plan
Filter Effluent Tank Sections
Filter Effluent Tank Details
Backwash Tanks Plan
Backwash Tanks Sections
Treatment Building Foundation Plan
Treatment Building Foundation Sections
Treatment Building Foundation Details
Treatment Building Plan
Treatment Building Elevations

MECHANICAL

Mechanical and Piping Symbols
General Arrangement
General Arrangement
General Arrangement
Groundwater Extraction and Equalization Process and Instrumentation Diagram (P&ID)
Bioreactor and Aeration Tank Piping Plan
Bioreactor and Aeration Tank Piping Elevations
Offgas Treatment System Piping Plan
Offgas Treatment System Piping Elevations
Media Filter Piping Plan
Media Filter Piping Elevations
Solids Handling System Piping Plan
Solids Handling System Piping Elevations
UV/Oxidation System Piping Plan
UV/Oxidation System Piping Elevations
Granular Activated Carbon System Piping Plan
Granular Activated Carbon System Piping Elevations
Disinfection Systems Piping Plan
Disinfection Systems Piping Elevations
Chemical Feed Systems Piping Plan
Chemical Feed Systems Piping Elevations
Miscellaneous Details
Miscellaneous Details

ELECTRICAL

Electrical Abbreviations and Symbols
Site Power Plan
Power and Grounding Layout
Lighting and Receptacles Plan
Instrumentation and Control Layout
Instrumentation and Control Layout
Instrumentation and Control Layout
One Line Diagram
One Line Diagram
One Line Diagram
Panel Layout
Panel Layout
Panel Layout
Panel Layout
Panel Layout
Control Schematics
Control Schematics
Control Schematics
Control Schematics
Control Schematics
Control Schematics
Control Schematics

PROCESS

Process and Instrumentation Symbols, Elements, and Legend

Process Flow Diagram

Process Flow Diagram

Groundwater Extraction and Equalization Process and Instrumentation Diagram (P&ID)

Bioreactor and Aeration Tank Process and Instrumentation Diagram (P&ID)

Offgas Treatment System Process and Instrumentation Diagram

Media Filter Process and Instrumentation Diagram (P&ID)

Solids Handling System Process and Instrumentation Diagram (P&ID)

UV/Oxidation System Process and Instrumentation Diagram (P&ID)

Granular Activated Carbon System Process and Instrumentation Diagram (P&ID)

Chemical Feed Systems Process and Instrumentation Diagram (P&ID)

Disinfection System Process and Instrumentation Diagram (P&ID)

PRELIMINARY LIST OF SPECIFICATIONS

DIVISION 1 - GENERAL REQUIREMENTS

Section 01010 - Summary of Work
Section 01025 - Measurement and Payment
Section 01035 - Modification Procedures
Section 01040 - Coordination
Section 01050 - Field Engineering
Section 01060 - Regulatory Requirements
Section 01080 - Identification Systems
Section 01091 - Reference Standards
Section 01092 - Abbreviations
Section 01093 - Symbols
Section 01094 - Definitions
Section 01110 - Hazardous Material Procedures
Section 01130 - Health, Safety, and Emergency Response
Section 01200 - Project Meetings
Section 01300 - Submittals
Section 01310 - Progress Schedule
Section 01320 - Progress Reports
Section 01330 - Survey and Layout Data
Section 01340 - Shop Drawings, Product Data, and Samples
Section 01360 - Quality Control Submittals
Section 01400 - Quality Control
Section 01500 - Construction Facilities and Temporary Controls
Section 01600 - Material and Equipment
Section 01630 - Product Options and Substitutions
Section 01650 - Installed Equipment Testing and Facility Startup
Section 01700 - Contract Closeout
Section 01710 - Final Cleaning
Section 01720 - Project Record Documents
Section 01730 - Operation and Maintenance Instructions
Section 01740 - Warranties and Bonds
Section 01750 - Spare Parts and Maintenance Materials
Section 01760 - Warranty Inspections
Section 01800 - Maintenance
Section 01900 - Decontamination and Materials Disposal
Section 01999 - Reference Forms

DIVISION 2 - SITE WORK

Section 02110 - Site Preparation
Section 02220 - Earthwork
Section 02225 - Trenching
Section 02231 - Aggregate Base Course
Section 02260 - Sub-base for Slab
Section 02831 - Chain-link Fences and Gates

DIVISION 3 - CONCRETE

Section 03000 - Concrete - General

DIVISION 4 - MASONRY

Not used.

DIVISION 5 - METALS

Section 05500 - Miscellaneous Metals

DIVISION 6 - WOOD AND PLASTIC

Not used.

DIVISION 7 - SEALANTS AND CAULKING

Section 07900 - Sealants

DIVISION 8 - DOORS AND WINDOWS

Not used.

DIVISION 9 - PROTECTIVE COATINGS

Section 09900 - Painting

DIVISION 10 - SPECIALTIES

Section 10522 - Fire Extinguishers

DIVISION 11 - EQUIPMENT

Section 11211 - Horizontal Centrifugal Pump

Section 11212 - Submersible Sump Pumps

Section 11213 - Air-operated Diaphragm Pumps

Section 11214 - Chemical Metering Pumps

Section 11240 - Chemical Feeding Equipment

Section 11302 - Clarifier

Section 11360 - Filter Press

Section 11501 - UV/Chemical Oxidation System

Section 11502 - Liquid-Phase Granular Activated Carbon Adsorbers

Section 11503 - Vapor-Phase Granular Activated Carbon Adsorbers

Section 11504 - Disinfection Equipment

Section 11505 - Filter Media

Section 11999 - Miscellaneous Equipment

DIVISION 12 - FURNISHINGS

Not used.

DIVISION 13 - SPECIAL CONSTRUCTION

Section 13440 - Prefabricated Metal Building
Section 13440 - Instrumentation for Process Control - General Statement
Section 13441 - Control Loop Descriptions
Section 13442 - Primary Elements
Section 13443 - Process Control System

DIVISION 14 - CONVEYANCE SYSTEMS

Not used.

DIVISION 15 - MECHANICAL

Section 15050 - Pipe Systems - General
Section 15060 - Pipe, Hose, and Fittings
Section 15090 - Flexible Couplings
Section 15100 - Valves
Section 15120 - Sample Taps
Section 15121 - Eyewash/Emergency Shower
Section 15140 - Pipe Supports and Anchors
Section 15141 - Equipment Supports and Anchors
Section 15175 - Polyethylene Tanks
Section 15176 - Atmospheric Steel Tanks

DIVISION 16 - ELECTRICAL

Section 16010 - Basic Electrical Requirements
Section 16111 - Conduit
Section 16120 - Wire and Cable
Section 16130 - Boxes
Section 16140 - Wiring Devices
Section 16190 - Supporting Devices
Section 16195 - Electrical Identification
Section 16410 - Power Factor Correction
Section 16420 - Service Entrance
Section 16440 - Disconnect Switches
Section 16445 - Control Auxiliaries
Section 16450 - Secondary Grounding
Section 16461 - Dry Type Transformers
Section 16470 - Panelboards
Section 16480 - Motor Controls
Section 16481 - Variable Frequency Drives
Section 16500 - Lighting
Section 16535 - Emergency Lighting Equipment
Section 16740 - Telephone System

DISTRIBUTION

Phase 2 Treatability Study Work Plan
Pilot-scale Groundwater Treatment System
Baldwin Park Operable Unit
San Gabriel Basin, California

October 29, 1998

Copy No.

Copies 1-33: Baldwin Park Operable Unit
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Copies 35-47: Other Interested Parties

Copies 47-53: HLA Project File

Quality Control Reviewer

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